

REMARKS

Claims 1 and 22 have been amended pursuant to an agreement reached with Primary Examiner Olsen during a telephone conversation with the undersigned on July 1, 2005.

Specifically, Claim 1 has been amended to recite, *inter alia*, "supplying an oxygen-free single-fluorocarbon etching gas to the chamber and energizing the etching gas into an plasma state, the etching gas consisting essentially of at least one nitrogen reactant, a single fluorocarbon reactant represented by C_nF_m wherein n is at least 4 and m is at least 6, and optional carrier gas." Claim 22 has been amended to recite, *inter alia*, "supplying an oxygen-free etching gas to the chamber and energizing the etching gas into a plasma state, the etching gas consisting essentially of C_4F_8 , CF_2H_2 , N_2 and optionally Ar." No new matter has been added and because no new issues are presented by the amendments, entry thereof is respectfully requested.

Reconsideration and allowance of the application are respectfully requested in light of the above amendments and the following remarks.

Rejection Under 35 U.S.C. § 103

- I -

Claims 1, 5-7, 9, 11, 14-16, 19-21, and 25 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over U.S. Patent No. 6,693,042 ("Sedigh"). The reasons for the rejection are stated on pages 2-3 of the Office Action. The rejection is respectfully traversed.

Sedigh is cited in the Office Action as disclosing: (1) a method that comprises the plasma etching of a low-k dielectric material such as fluorine-doped silicon oxide; (2) using an etchant comprising a hydrofluorocarbon, for example, $C_xH_yF_z$ wherein $x \geq 2$, $y \geq 2$, and $z \geq 2$; (3) that nitrogen and other fluorinated compounds such as CF_4 , C_4F_8 , C_4F_6 , and C_5F_8 may be added to the etchant; (4) that in one embodiment, CF_4 is used at a flow rate of 10-60 SCCM and nitrogen at a flow rate of 5-25 SCCM; (5) patterning the dielectric etching by etching through an overlying hard masking material, such as undoped silicon oxide; (6) that the dielectric layer overlies a conductive layer, for example, aluminum; (7) etching patterns with features smaller than 0.2 microns; (8) that the method is part of a damascene process in which the etched feature is subsequently filled with metal; and (9) using an apparatus with high and low frequency RF power.

Sedigh does not disclose the combination of features recited in Claim 1, which include, *inter alia*, an oxygen-free single-fluorocarbon etching gas consisting essentially of at least one nitrogen reactant, a single fluorocarbon reactant represented by C_nF_m wherein n is at least 4 and m is at least 6, and optional carrier gas.

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. MPEP § 2142.

Applicants respectfully submit that Sedigh does not disclose or suggest all the claim limitations of Claim 1. Specifically, Sedigh does not disclose or suggest an oxygen-free single-fluorocarbon etching gas consisting essentially of at least one nitrogen reactant, a single fluorocarbon reactant represented by C_nF_m wherein n is at least 4 and m is at least 6, and optional carrier gas. Rather, Sedigh discloses a combination of fluorocarbons ($C_2H_2F_4$, CF_4 , and CHF_3), none of which are represented by C_nF_m wherein n is at least 4 and m is at least 6.

In accordance with the initial indication given by Primary Examiner Olsen in a telephone conversation with the undersigned on July 1, 2005, during which the amendments to Claims 1 and 22 were discussed, withdrawal of the rejection under 35 U.S.C. § 102(e) is respectfully requested.

- II -

Claims 22 and 23 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over U.S. Patent No. 5,843,847 ("Pu"). The reasons for the rejection are stated on page 4 of the Office Action. The rejection is respectfully traversed.

Pu is cited in the Office Action as disclosing: (1) a method of plasma etching doped glasses such as PSG and BPSG; (2) an oxide to resist selectivity of at least 10:1; (3) an etchant composition comprising a fluorocarbon selected from a second group that includes C_4F_8 , a fluorocarbon selected from a first group that includes CF_2H_2 , and N_2 ; (3) a $N_2:(C_4F_8+CF_2H_2)$ flow ratio of up to 5:1 and a $CF_2H_2:C_4F_8$ ratio of 1:1.

The Office Action acknowledges that Pu does not disclose the combination of C_4F_8 and CF_2H_2 , but asserts that it would have been obvious to one skilled in the art to use the $C_4F_8+CF_2H_2$ combination because C_4F_8 is identified as the preferred

fluorocarbon from the second group and CF_2H_2 is but one of five fluorocarbons which belong to the first group.

Pu discloses a process gas comprising (i) fluorocarbon gas for etching the dielectric layer and for forming passivating deposits on the substrate, (ii) carbon-oxygen gas for enhancing formation of the passivating deposits, and (iii) nitrogen-containing gas for etching the passivating deposits on the substrate. (Abstract)

Claim 22 has been amended to recite, *inter alia*, "supplying an oxygen-free etching gas to the chamber and energizing the etching gas into a plasma state, the etching gas consisting essentially of C_4F_8 , CF_2H_2 , N_2 and optionally Ar." Oxygen degradation of low-k films can be minimized by using an oxygen-free etch gas for etching organic low-k material. (Page 18, Lines 11-14) Further, oxygen-free etch gas avoids etching the silicon carbide layer. (Page 19, Lines 9-11)

Applicants respectfully submit that Pu does not disclose or suggest all the claim limitations. Specifically, Pu does not disclose or suggest an oxygen-free etching gas consisting essentially of C_4F_8 , CF_2H_2 , N_2 and optionally Ar. Rather, Pu discloses a process gas comprising a carbon-oxygen gas.

In accordance with the initial indication given by Primary Examiner Olsen in a telephone conversation with the undersigned on July 1, 2005, during which the amendments to Claims 1 and 22 were discussed, withdrawal of the rejection under 35 U.S.C. § 103(a) is respectfully requested.

- III -

Claim 24 stands rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Pu in view of Koshiishi. The reasons for the rejection are stated on pages 4-5 of the Office Action. The rejection is respectfully traversed.

The Office Action acknowledges that Pu does not disclose a dual frequency plasma system.

Koshiishi is cited in the Office Action as disclosing etching in a dual frequency plasma system wherein the pedestal electrode and the showerhead electrode are provided with different frequencies of RF energy.

The Office Action asserts that it would have been obvious to one skilled in the art to use the RF frequency scheme of Koshiishi because Koshiishi teaches that this enables greater control over the etching process.

Applicants respectfully submit that Pu in view of Koshiishi does not disclose or suggest all the claim limitations. Specifically, Pu does not disclose or suggest an oxygen-free etching gas. Rather, Pu discloses a process gas comprising a carbon-oxygen gas. Koshiishi, cited as disclosing etching in a dual frequency plasma system, does not cure the deficiencies of Pu in this regard.

In accordance with the initial indication given by Primary Examiner Olsen in a telephone conversation with the undersigned on July 1, 2005, during which the amendments to Claims 1 and 22 were discussed, withdrawal of the rejection under 35 U.S.C. § 103(a) is respectfully requested.

- IV -

Claims 1-3, 5-7, and 9-25 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over U.S. Patent No. 6,455,411 ("Jiang") in view of Koshiishi. The reasons for the rejection are stated on pages 5-7 of the Office Action. The rejection is respectfully traversed.

Jiang is cited in the Office Action as disclosing: (1) plasma etching a low-k dielectric layer; (2) using an etchant comprising a fluorocarbon and a greater amount

of nitrogen; (3) etching low-k dielectric layers through an overlying patterned layer of SiN, which functions as a mask for the subsequent etching of the underlying layer of low-k dielectric; (4) etching a layer of low-k dielectric that is disposed upon an underlying layer of SiC; (5) C₄F₈, C₄F₆, and CH₂F₂ as fluorocarbon etchants; (6) adding Ar to the etchant; (7) an etchant mixture consisting of C₄F₈, N₂, and Ar; (8) etching a layer of low-k dielectric material that overlies a barrier layer comprising TaN; (9) using a fluorocarbon flow rate that is less than 30% of the nitrogen flow rate; and (10) that the etched feature is filled with metal.

The Office Action acknowledges that Jiang does not disclose: (1) etching a feature with at least a 5:1 aspect ratio; (2) a dual frequency plasma system; (3) using an etchant that consists essentially of C₅F₈, N₂, and Ar, or (4) the temperature of the substrate support.

Koshiishi is cited as disclosing etching in a dual frequency plasma system wherein the pressure is up to 11 Pa and the pedestal and showerhead electrodes are provided with different frequencies of RF energy.

The Office Action asserts that it would have been obvious to one skilled in the art to use the RF frequency scheme of Koshiishi because Koshiishi teaches that this enables greater control over the etching process.

The Office Action asserts that it would have been obvious to one skilled in the art to appropriately adjust the process parameters such as the temperature of the substrate because optimization of such parameters is considered to be obvious.

Jiang discloses a dual damascene process for low-k or ultra low-k dielectric. (Abstract) Jiang discloses a via etch followed by trench etch. (Column 2, Lines 8-12) The via etch chemistry preferably comprises C₅F₈, N₂ and CO. (Column 3,

Lines 24-26) The trench etch chemistry comprises a less-polymerizing fluorocarbon with a more-polymerizing fluorocarbon, nitrogen and argon. (Column 3, Lines 45-47) A less-polymerizing fluorocarbon refers to a C:F ratio of less than 1:3, examples of which include CF_4 , C_2F_6 , and $\text{C}_x\text{F}_{3x+y}$ ($Y \geq 0$), and examples of more-polymerizing fluorocarbons include C_4F_8 , C_5F_8 , C_4F_6 , $\text{C}_x\text{H}_y\text{F}_{2x+z}$ ($Z \geq 0$, $Y \geq 0$). (Column 3, Lines 50-52) The combined fluorocarbons improve etch rate without increasing oxide ridges or increasing CD bias. (Column 4, Lines 8-9) Jiang further discloses that various C:F ratios can be achieved by adjusting the flow rate of the two fluorocarbons, which is not possible with a single fluorocarbon. (Column 4, Lines 18-21)

A prior art reference must be considered in its entirety, *i.e.*, as a whole, including portions that would lead away from the claimed invention. *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984).

Applicants respectfully submit that Jiang teaches away from the process of independent Claim 1, which recites, *inter alia*, an oxygen-free single fluorocarbon etching gas consisting essentially of at least one nitrogen reactant, a single fluorocarbon reactant represented by C_nF_m wherein n is at least 4 and m is at least 6, and optional carrier gas, for etching openings while providing an etch rate selectivity of the etching rate of a low-k dielectric layer to the etching rate of a mask layer of at least about 5. Rather, Jiang discloses a via etch chemistry comprising CO and a trench etch chemistry comprising a less-polymerizing fluorocarbon (C:F ratio of less than 1:3) with a more-polymerizing fluorocarbon.

Applicants respectfully submit that Jiang in view of Koshiishi does not disclose or suggest all the claim limitations of independent Claim 1. Specifically, Jiang in view of Koshiishi does not disclose or suggest an oxygen-free single fluorocarbon etching gas, consisting essentially at least one nitrogen reactant, a single fluorocarbon reactant represented by C_nF_m wherein n is at least 4 and m is at least 6, and optional carrier gas, for etching openings while providing an etch rate selectivity of the etching rate of a low-k dielectric layer to the etching rate of a mask layer of at least about 5. Koshiishi, cited as disclosing etching in a dual frequency plasma system, does not cure the deficiencies of Jiang in this regard.

Applicants further respectfully submit that Jiang teaches away from the process of independent Claim 22, which recites, *inter alia*, an oxygen-free etching gas consisting essentially of C_4F_8 , CF_2H_2 , N_2 and optionally Ar, the C_4F_8 , CF_2H_2 and N_2 being supplied to the chamber at flow rates such that the total C_4F_8 and CF_2H_2 flow rate is 30% or less of the N_2 flow rate, for etching openings while providing an etch rate selectivity of the etching rate of a low-k dielectric layer to the etching rate of a mask layer of at least about 5. Again, Jiang discloses a via etch chemistry comprising CO and a trench etch chemistry comprising a less-polymerizing fluorocarbon (C:F ratio of less than 1:3) with a more-polymerizing fluorocarbon.

Applicants further respectfully submit that Jiang in view of Koshiishi does not disclose or suggest all the claim limitations of independent Claim 22. Specifically, Jiang in view of Koshiishi does not disclose or suggest an oxygen-free etching gas consisting essentially of C_4F_8 , CF_2H_2 , N_2 and optionally Ar, the C_4F_8 , CF_2H_2 and N_2 being supplied to the chamber at flow rates such that the total C_4F_8 and CF_2H_2 flow rate is 30% or less of the N_2 flow rate, for etching openings while providing an etch

rate selectivity of the etching rate of a low-k dielectric layer to the etching rate of a mask layer of at least about 5. Koshiishi, cited as disclosing etching in a dual frequency plasma system, does not cure the deficiencies of Jiang in this regard.

In accordance with the initial indication given by Primary Examiner Olsen in a telephone conversation with the undersigned on July 1, 2005, during which the amendments to Claims 1 and 22 were discussed, withdrawal of the rejection under 35 U.S.C. § 103(a) is respectfully requested.

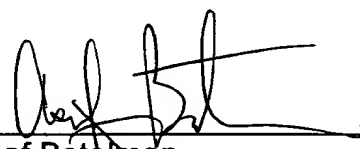
Conclusion

Therefore, allowance of the application is respectfully requested. Should the Examiner desire to discuss this application, the undersigned attorney can be reached at the telephone number given below.

Respectfully submitted,

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